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INFRARED
model 603

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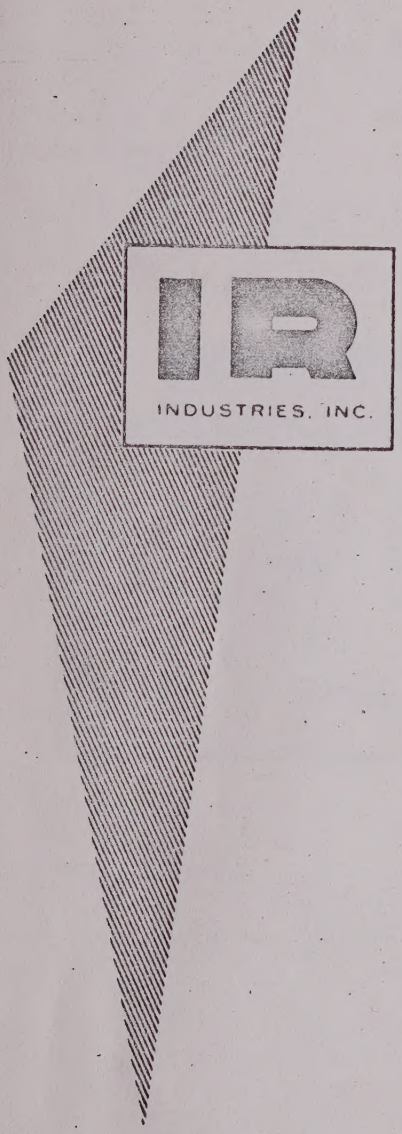


OPERATIONS MANUAL

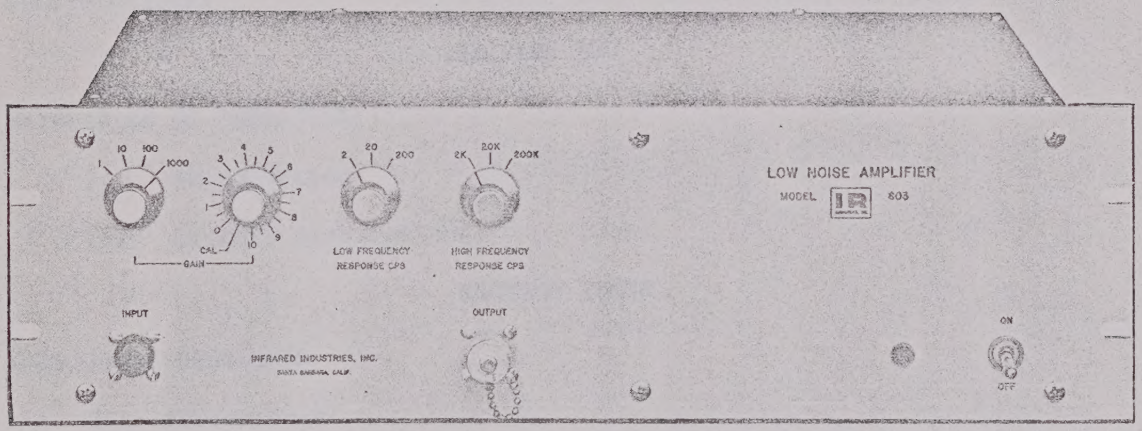
a SV

IRI MODEL 603

LOW NOISE AMPLIFIER

Serial No. 128

INFRARED INDUSTRIES, INC. SANTA BARBARA, CALIFORNIA



IRI MODEL 603

Low Noise Amplifier

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SECTION ONE

SPECIFICATIONS

LOW NOISE AMPLIFIER MODEL 603

ELECTRICAL

Bandwidth: 2 cps - 200K cps (-3db) (See response curves on Figure 1-1)

Note: Field service, or customer supplied input cables may vary high frequency response.

Three position low pass filter: 200K cps, 20K cps, 2K cps (-3db)

Three position high pass filter: 2 cps, 20 cps, 200 cps (-3db)

Short circuit equivalent noise per cycle bandwidth: (See Figure 1-2)

@ 10 cps = .035 microvolt/cycle $^{\frac{1}{2}}$
@ 90 cps = .015 microvolt/cycle $^{\frac{1}{2}}$
@ 1000 cps = .008 microvolt/cycle $^{\frac{1}{2}}$

Triaxial low capacity input cable.

Input impedance: 40 megohms minimum shunted by 25 picofarads maximum at input connector.

Gain:

Maximum = 5000 $\pm$ 10%
Input attenuator: 4 positions X1000, X100, X10, X1
Fine gain control: 20:1 range minimum

Attenuator accuracy: $\pm$ 1% of reading, 2 cps to 100 KC

Maximum input voltage: 10 mv 100 mv for gain less than 100.

Maximum output voltage: 10 volts RMS

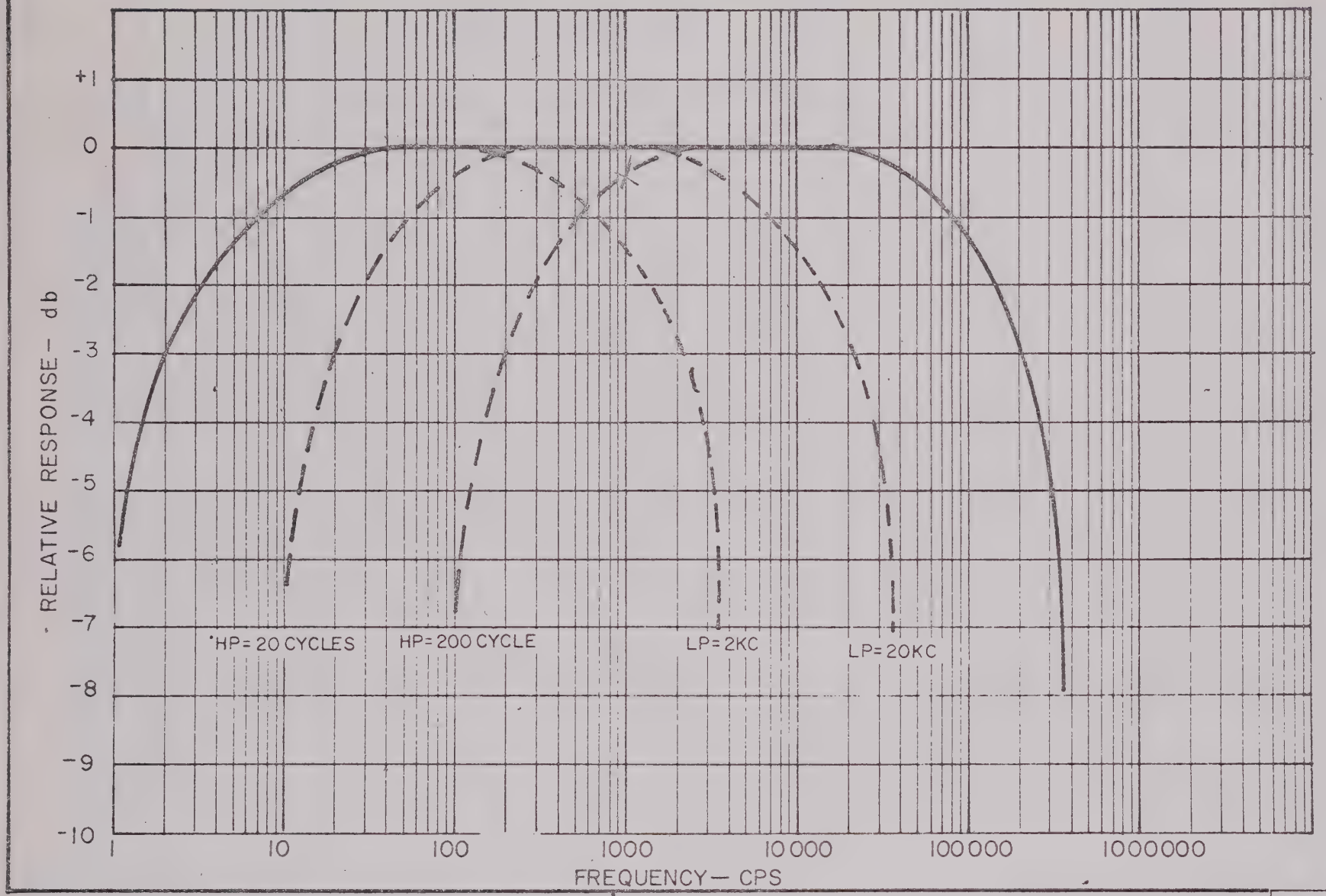
Coaxial output connector (amphenol 83-1R)

Output impedance: 800 ohms maximum

7 Tubes

Regulated B+ and D. C. Filaments

Power Requirements: 117 VAC @ 0.6 amperes, 60 cycles



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IRI MODEL 603 LOW NOISE AMPLIFIER
TYPICAL FREQUENCY RESPONSE 0 db = .775 VOLTS
RELATIVE OUTPUT Vs. FREQUENCY FIG. 1-1

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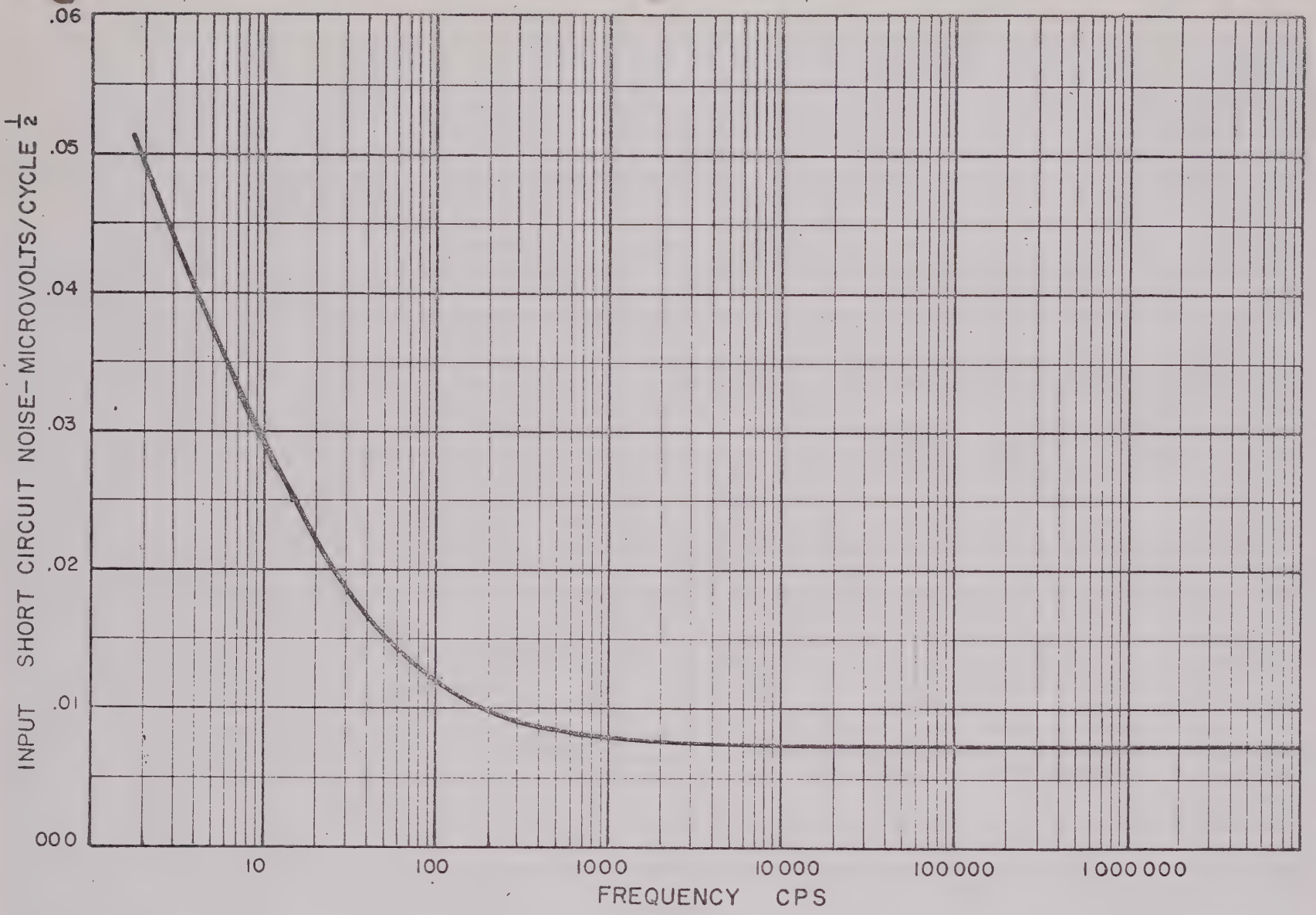

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IRI MODEL 603 LOW NOISE AMPLIFIER
TYPICAL NOISE SPECTRUM- MICROVOLT/CYCLE $\frac{1}{2}$
SHORT CIRCUIT NOISE Vs. FREQUENCY FIG. 1-2

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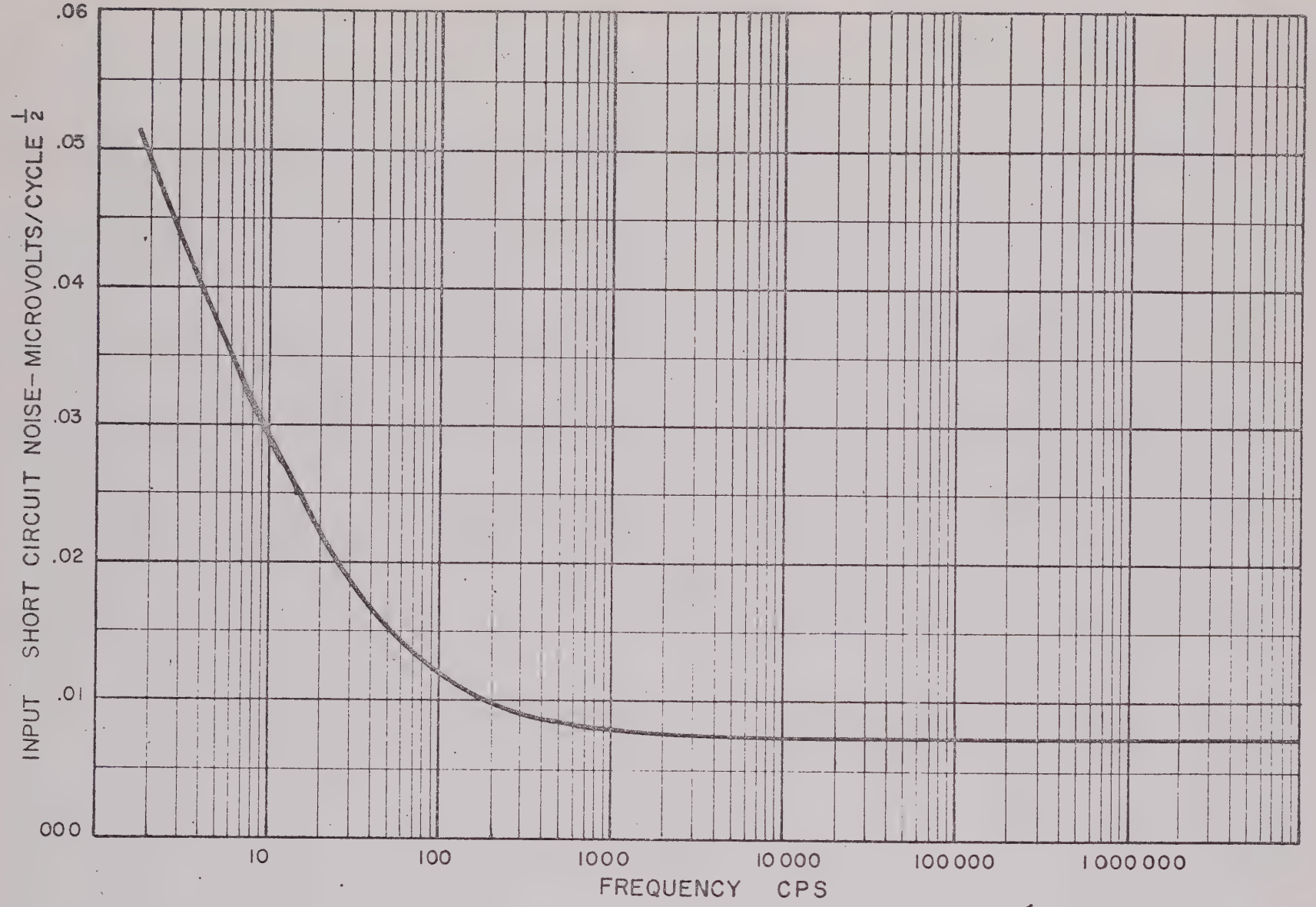

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IRI MODEL 603 LOW NOISE AMPLIFIER
TYPICAL NOISE SPECTRUM- MICROVOLT/ CYCLE $\frac{1}{2}$
SHORT CIRCUIT NOISE Vs. FREQUENCY FIG. 1-2

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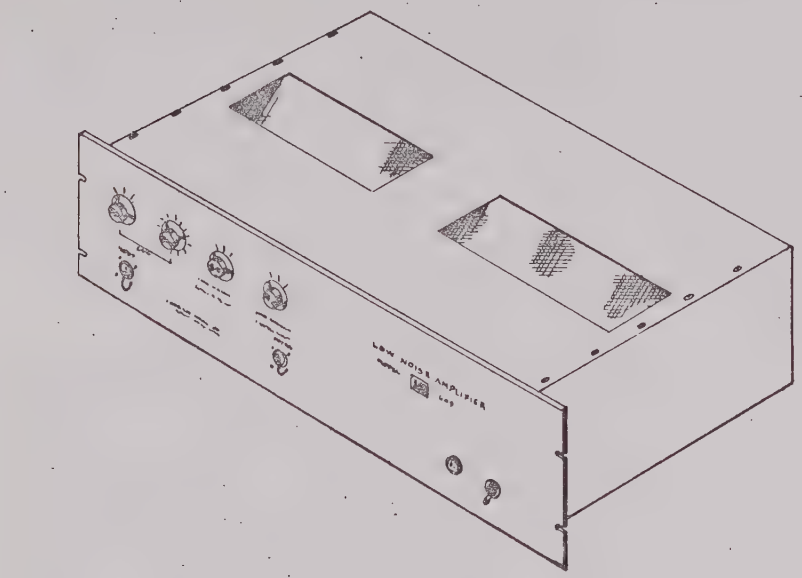
MECHANICAL

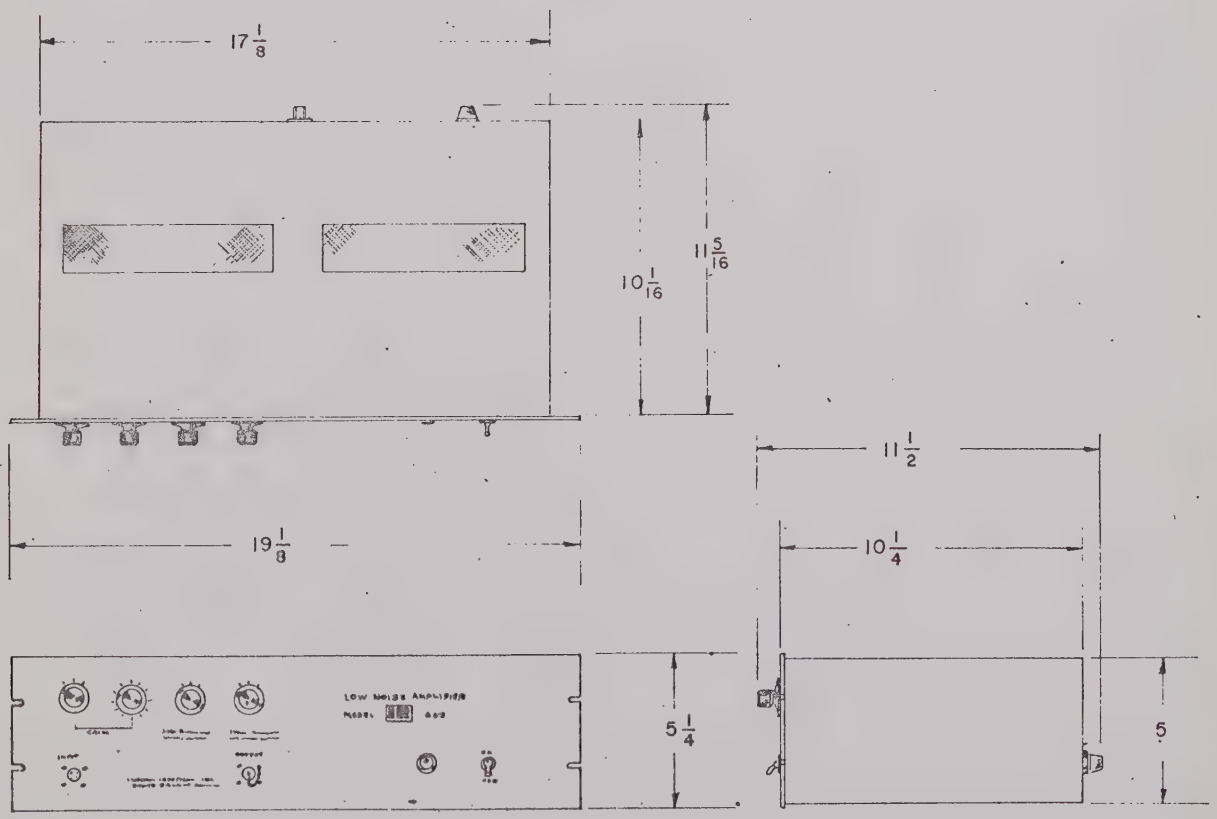
Size: 19 1/8"X x 11 1/2"D (behind panel) x 5 1/4

Note: These are overall dimensions; See Figure 1-3

Weight: Rack mounted - 18 lbs.

Cabinet mounted - 35 lbs.





IRI MODEL 603 LOW NOISE AMPLIFIER
OUTLINE DRAWING

Fig. 1-3

SECTION TWO

PRINCIPLES OF OPERATION

2.1 INTRODUCTION

The Infrared Industries, Inc. Model 603 Amplifier is a low noise, wideband unit intended for use in a system as a low level preamplifier.

The fine gain control with its 20 to 1 range in combination with the decade step input attenuator provides a gain range from 0.2 to 4,000 so that input signals from the microvolt region to approximately 0.1 volts may be accommodated and read directly on most voltmeters. The wide range of the fine gain control allows an entire system to be calibrated to the nearest decade range of gain in terms of the equivalent open circuit output of the signal transducer. The fine gain control, when rotated completely counterclockwise so that the CAL switch is engaged, sets the gain of the instrument to 1000 $\pm$ 1%, for a gain range switch setting of X1000. This feature facilitates the use of the instrument for rapid absolute signal level measurements.

The low pass filter allows the basic bandwidth of the amplifier to be set to either 2KC, 20KC, or 200KC so that for single frequency signal measurements the wide-band noise may be reduced. The high pass filter allows low frequency noise such as flicker noise and 60 cycle or 120 cycle power line interference to be rejected. Each filter consists of a signal RC network so that the attenuation introduced by the filter approaches 6 db/octave.

If in some systems it is found necessary or desirable to unground the unit from the power line ground, this may be accomplished either by using a three pin female to two pin male adapter on the line cord, or by removing the ground wire from the line cord receptacle inside the chassis.

This unit has been thoroughly inspected and tested at the factory prior to shipment and it is operational as received.

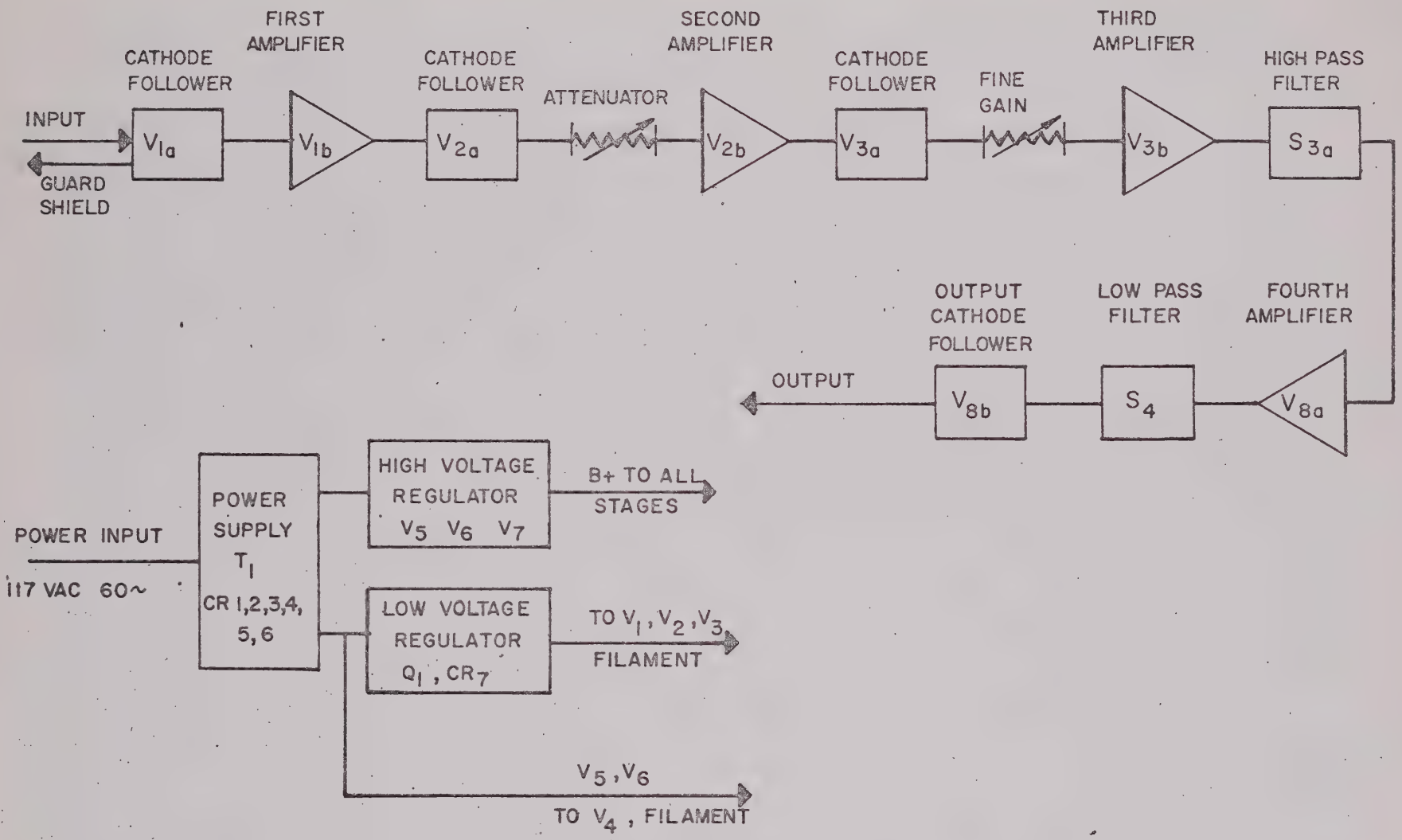
2.2 CIRCUIT DESCRIPTION

2.2.1 Power Supply - General (Refer to Block Diagram, Figure 2-1 and Schematic, Figure 2-2)

In low level, low noise amplifiers it is necessary to provide as much isolation as possible from outside disturbances, such as all types of noise which may be on the power line (spikes, RF noise and long term line voltage changes) and excessive electrostatic and electromagnetic radiation. Consequently, it is important to supply the low level amplifying stages with quiet, well regulated B+ and filament voltages. For gain stability in the absence of overall feedback from output to input, it is necessary to supply critical stages with a regulated filament supply.

2.2.2 High Voltage Power Supply

The power transformer, T1, drives the high voltage rectifiers, CR1, CR2, CR3 and CR4, connected as a full wave center tap circuit. The raw DC from these rectifiers is partially filtered by C25,and further smoothed by L1. The relatively smooth DC at the output of L1 is fed to V5 which is a parallel connected twin triode, used as a series regulator. A portion of the output current from V5 is bled off through R44 to supply a relatively steady ignition current to the reference tube, V7. This ignition current for V7 must be large with respect to the cathode current of V6, the difference amplifier, so that the reference voltage will not be an appreciable function of the required regulating cathode current of V6. R40 and R41 form a voltage divider from the regulated output of V5 to set the grid voltage of V6. The value is that required to cause a plate current in V6 such that the grid voltage of V5 causes the output voltage of V5 to be the desired (175VDC) regulated value. If the output voltage of V5 were to rise, this rise would cause the grid voltage of V6 to go slightly more positive, causing a greater plate current and hence a lower plate voltage on V6. This lower plate voltage on V6 implies a more negative grid voltage on



IRI MODEL 603 BLOCK DIAGRAM

FIG. 2-1

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V5, which would reduce the cathode voltage on V5 and hence tend to cause the output of V5 to remain constant. V6 is therefore amplifying the difference between the reference as established by V7 and the supply output signal as determined by R40 and R41. R42 and R43 are trimming resistors to allow the supply output voltage to be set to exactly the required value. The regulator responds in a similar way for an increase in plate voltage of V5. C27, C28 and C29 are used for further filtering to reduce the noise on the supply output caused by the noise generated in V5, V6 and primarily V7. These filter capacitors also decouple the amplifier stages from one another to prevent low frequency oscillation.

2.2.3 Low Voltage Filament Supply

The low voltage output of T1 is full wave center tap rectified by CR5 and CR6 and smoothed by C23. A portion of the output of CR5 and CR6 is fed through R32 to supply the bias current for CR7 and the base current for Q1. The bias current for CR7 must be large compared to the base current of Q1 so that the voltage of CR7 (reference voltage) will be relatively independent of the variation in bias current through CR7, caused by variations in the base current of Q1. The rest of the output of CR5 and CR6 is fed to the collector of Q1 and to the dropping resistor (R39) and the filaments of V4. For V4 to sustain high levels of output signal for long periods of time, it requires the highest attainable transconductance, which demands high, but quiet, filament voltage. The filaments of V1, V2, and V3 are essentially an emitter load for Q1, connected as an emitter follower with a fixed base voltage. Except for the variations in the emitter-base diode voltage of Q1 as a function of temperature and emitter current (which are small compared to the emitter to common or filament voltage) the emitter voltage of Q1 will be maintained approximately equal to the Zener voltage of CR7. V1, V2, V3 are operated at reduced filament voltage to extend the life

of these relatively critical stages as well as to increase the gain of and to reduce the noise from these stages. The gain of V1 is enhanced approximately 15% by the lower than normal filament voltage, and the gain is less sensitive to small changes in filament temperature.

With reference to the schematic, Figure 2-2, the primary of T1 may be reconnected for line voltages of 104, 208 and 230 VAC.

2.2.4 Amplifier

The input signal is fed from pin 1 of the input connector through the input coupling capacitor, C1, to the grid of the input cathode follower, V1a. V1a is connected as a cathode follower to provide the required high input impedance and to provide the low output impedance required to drive V1b. In addition to the impedance transformation (and current multiplication) obtained from V1a, the cathode follower connection allows a connection to be made to the cathode of V1a to obtain a reflection of the input signal but of much higher power. This signal from the cathode of V1a is used to drive V1b and also the inner shield of the triaxial input cable. By surrounding the input, or signal carrying, conductors of the input cable with a current carrying shield that is at approximately signal potential rather than ground potential, the actual effective capacitance from the signal conductor to ground may be greatly reduced. In the Model 603, the driven shield arrangement will reduce effective input cable capacitance to about one fifth of the actual cable capacitance. As long as this "bootstrap" voltage remains in phase with, and of less amplitude than the input signal the stage will remain stable.

The signal from the cathode of V1a is fed through a coupling capacitor, C32, to the grid of V1b, the first voltage amplifier. V1b operates solely with grid leak bias, and because of this mode of operation, with no cathode degeneration the gain of the stage is rather high, the input impedance is usually low, and the

output impedance is rather high. The primary advantages of this mode of operation are the high gain and the very low equivalent input noise. Because of the high output impedance of V1b, direct coupling to V2a is advantageous in reducing stray capacitance associated with the components of a coupling network. V2a is operated as a cathode follower to present a high impedance to V1b and to provide a low output impedance for driving the attenuator, S2.

The attenuator is AC coupled to V2a via C33 so that the switching transcients will not saturate the remaining stages. A low impedance attenuator string (R10, R11, R12 and R13) is used to take advantage of the low output impedance of V2a, and to help hold frequency compensation of the attenuator to a minimum. C10, C30, C34 and C36 are the frequency response compensators for the attenuator (course gain) and they are adjusted individually for optimum desired frequency response for each amplifier.

The signal from the attenuator is AC coupled through C12 to the grid of V2b, the second voltage amplifier. This stage obtains its bias from the cathode resistor which also aids the stability of the stage by providing degeneration. The output from V2b is AC coupled to the grid of V3a, an emitter follower providing low output impedance to drive the fine gain control. Since the input and output impedance requirements for V3a are not as severe as they were for V2a, V3a is allowed to stabilize and bias itself with the regeneration provided by R20. The output from V3a is AC coupled to the fine gain control network, R21, R22 and R31. With the "CAL" switch in the closed position (fine gain control in any position of rotation except maximum counterclockwise rotation), the dynamic range of the fine gain control is established by R21 and R22. This dynamic range is intentionally large (greater than 20 to 1) so that the range of this control more than overlaps the decade ranges of the attenuator. With maximum counterclockwise rotation of the fine gain control, the "CAL" switch is opened and the range of this control is determined by R21, R22 and R31 and R31 is

factory set for an overall gain of 1000 in the mid frequency band.

The signal output from the fine gain control is AC coupled to the grid of V3b, the third voltage amplifier. This stage (V3b) operates almost identically to V2b, except that the output of this stage drives the high pass filter (C16, C17, or C18 and S1). These high pass filter capacitors also provide AC coupling of the signal to the grid of V4a. The grid input resistance of V4a is kept low (R26) so that the reactive component of the input impedance of V4a will be negligible at all frequencies of interest. The cathode degeneration and bias resistor for V4a is partially bypassed for high frequency compensation. The output of V4a is direct coupled to the grid of the output cathode follower, V4b, through R38. This mode of coupling helps to reduce stray coupling capacitance to ground which would disturb the operation of the low pass filter (C19, C20 or C21 and S4).

The output cathode follower, V4b is operated at low bias to reduce the output impedance. The output of this stage is AC coupled to the output connectors. The signal from the output connector is in phase with the input signal.

Each stage or pair of critical stages is separately decoupled from B+ to hold unwanted feedback through the power supply to a minimum, and also to make the supply for each tube, particularly V1 and V2, as quiet as possible. It should be noticed that the ground return of each of the decoupling capacitors returns to ground only in the vicinity of the stage it decouples.

SECTION THREE

OPERATING PROCEDURES

3.1 PRECAUTIONS

This instrument has been carefully inspected and aligned at the factory; it is warranted operation as received. Operation should not be attempted until the contents of this manual are understood, and adjustments should not be attempted except by experienced personnel, familiarized with the instrument. Should initial operating difficulty be encountered, or should the instrument require service over its operating life, the procedures given in Section Four of this manual will be a helpful guide. In any event, consultation with Infrared Industries Inc., Radiation Electronics Division is encouraged.

There are a number of precautions to be observed in connecting this instrument to a signal source. Since making or breaking input connections always causes large transients at the input of the amplifier, it is suggested that before an input connection is made or broken, that the attenuator be turned to the "X1" position. If the attenuator is not turned to the "X1" position, these large transients may severely overload the amplifier stages following the attenuator. These stages may require as long as thirty seconds to completely recover from severe overload.

3.2 OPERATION

To place the unit in operation it is necessary only to plug the unit into a source of 117 VAC, 60 cycle power and turn it on. In order to use the amplifier for making a measurement, it is necessary to provide some type of voltmeter or oscilloscope as a readout and connect it to the amplifier output.

When the instrument is used as a component of a system, or for preliminary measurements on a new set-up, it is advisable to use an oscilloscope

connected to the AC output jack. The use of an oscilloscope will aid system checkout and it will help to determine whether or not power system or signal ground loops exist. If a power system ground loop exists, it may be impossible to measure noise on a transducer because of the stray 60 cps signals affecting the instrument. The signal return system is connected from pin 3 of the input connector to chassis ground at one point, and only one point, inside the amplifier. This should be the only connection between signal return and chassis ground. Note that the input connectors are not grounded to the front panel. The instrument may be removed from power system ground either by using a three pin female-to-two pin male line cord isolator on the end of the line cord, or by removing the bottom plate from the chassis and disconnecting the wire on the center terminal of the power connector. It is not advised that the ground pin on the receptacle end of the power cord be removed. Generally, when power system ground loops are absent, signal ground loops will also be absent, except possibly for signal calibration equipment.

The setting of the high pass and the low pass filter is solely a function of the test and system requirements. In general, if the instrument is used in a system that is bandwidth limited by another instrument such as a tuned filter or a wave analyzer, the high frequency and low frequency response controls should be set so that this instrument attenuates the passband outside of the passband of the filter as greatly as possible without affecting the passband of the filter.

Most low level instrumentation systems are quite sensitive to signal and/or power system ground loops, and stray electrostatic and electromagnetic radiation. Due precautions must be taken to properly shield the input signal source, the input cable, and the instrument itself from excessive electromagnetic radiation.

In order to know the absolute value of the signal or noise voltage being read by the instrument, it is necessary that the instrument be calibrated to a known value of gain or in terms of the equivalent open circuit output of the transducer.

In order to calibrate the instrument to some known value of gain it will also be necessary to supply an input signal of known frequency and known amplitude of 10 millivolts or less so that the gain of the amplifier may be set to some desired value. If the amplifier is being used with a cathode follower, this calibration should be from end to end, that is from the input of the cathode follower to the readout device. It is important to remember that the amplifier output voltage should not exceed 15 volts zero to peak.

An equivalent open circuit calibration may be established directly by inserting a signal generator in series with the signal return of the transducer and the signal common for the instrument. The ground side of the generator should be connected to pin 3 of the input connector, and the hot side of the generator should be connected to the ground side of the transducer. The generator must have a known output voltage between 0.100 volts and 100 microvolts and have a source impedance negligibly small with respect to the transducers impedance. With this arrangement connected to the instrument, the fine gain control and the attenuator are set so that the readout instrument (scope or VTV14) reads the calibration voltage. With the calibration signal removed, the instrument will read the transducer output as though it were connected to a voltmeter of infinite input impedance, regardless of load resistance. If the signal frequency or the transducer impedance is changed, a new E.O.C. calibration is required. Input cable should be of the low noise type (Microdot CV 50-3833 or equivalent). For further recommendation concerning calibration, factory consultation is available and encouraged.

SECTION FOUR

MAINTENANCE

This instrument has been designed with a long service life in mind. Most of the components operate well within their specified ratings. However, as with any instrument with vacuum tubes and mechanical components, eventually, maintenance and repairs will be necessary. All identical or equivalent replacement parts may be purchased from IRI. The part description, value, and schematic identifying number are necessary for ordering replacements.

4.1 INPUT STAGE

It is possible to damage the input coupling capacitor, C1, if it is severely overvoltaged. If this capacitor is broken down due to severe overvoltage, it may develop excessive leakage, but not so bad as to be evident on a capacitor checker. This leakage will cause excessive noise under shorted input or signal measurement conditions, but not under open input circuit conditions. The input tubes, V1 and V2, have been aged and selected for low noise operation. Since the filaments of V1 and V2 are operated nearly 25% below their nominal ratings, these tubes should last for a very long time. Should V1 and V2 need replacing, it is suggested that they be purchased from IRI or that they be replaced only with Telefunken ECC83. The above comments also apply to V3.

4.2 SWITCHES AND CONTROLS

If the instrument is operated in a dust-laden environment, after many hours of operation the selector switches may appear to become intermittant. They may be cleaned and returned to normal operation by using any good contact cleaning solution. Periodically the attenuator switch and the contacts should be checked for wear. If the switch has a "gritty" feel to it, the detent mechanism and the contacts should be lubricated with a high quality silicon grease. The proper grease on the contacts does not interfere with the

electrical operation of the switch. Standard controls such as the fine gain control (R22), are standard items which are available at most electronics parts houses.

4.3 MAIN AMPLIFIER

If V1, V4, V6 and V7 are replaced, the DC voltages for these tubes should be checked. The replacements for V1, V2 and V6 should be aged before they are installed in the instrument. All other tubes in the instrument are non-critical, and may be replaced by the same type or any brand.

4.4 PRECAUTIONS

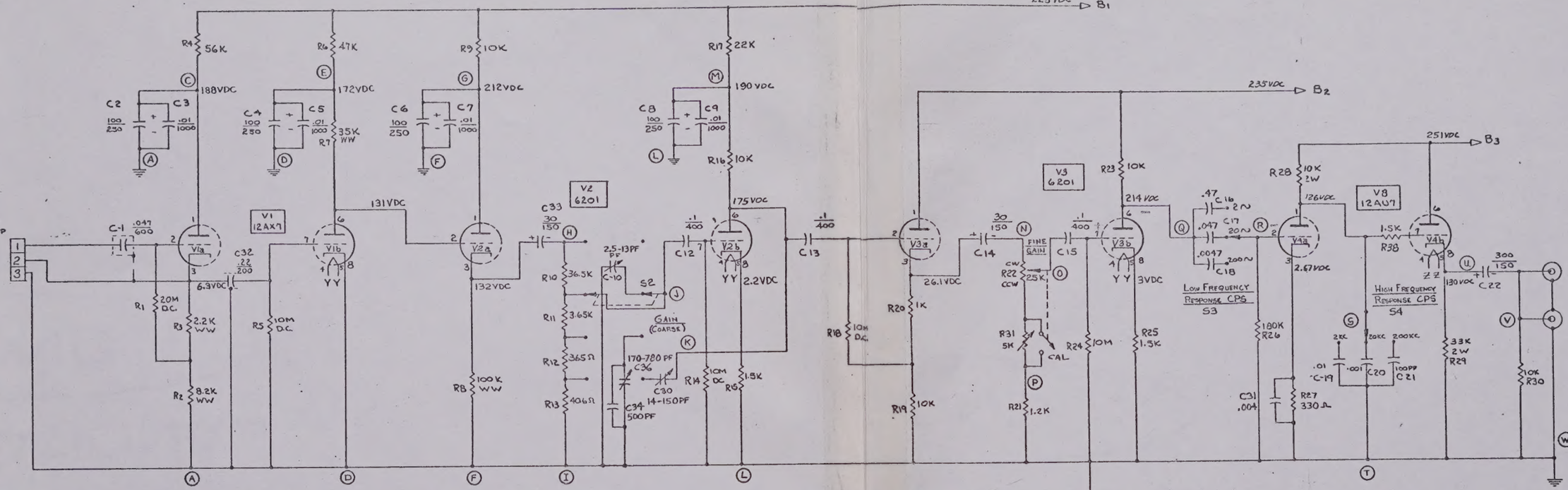
The circuit is relatively simple and straightforward so that should trouble develop, a competent technician familiar with audio amplifiers should have little trouble remedying the trouble. Should any of the solid state components such as the silicon rectifiers, the Zener diode or the transistor need replacing, a heat sink should be used when soldering to the leads of these components. In replacing the transistor care must be taken to make certain that the case of the transistor (the collector) does not short to chassis. It is recommended that the transistor, the insulating wafer and the chassis underneath the wafer be recoated with silicon grease when replacing the transistor.

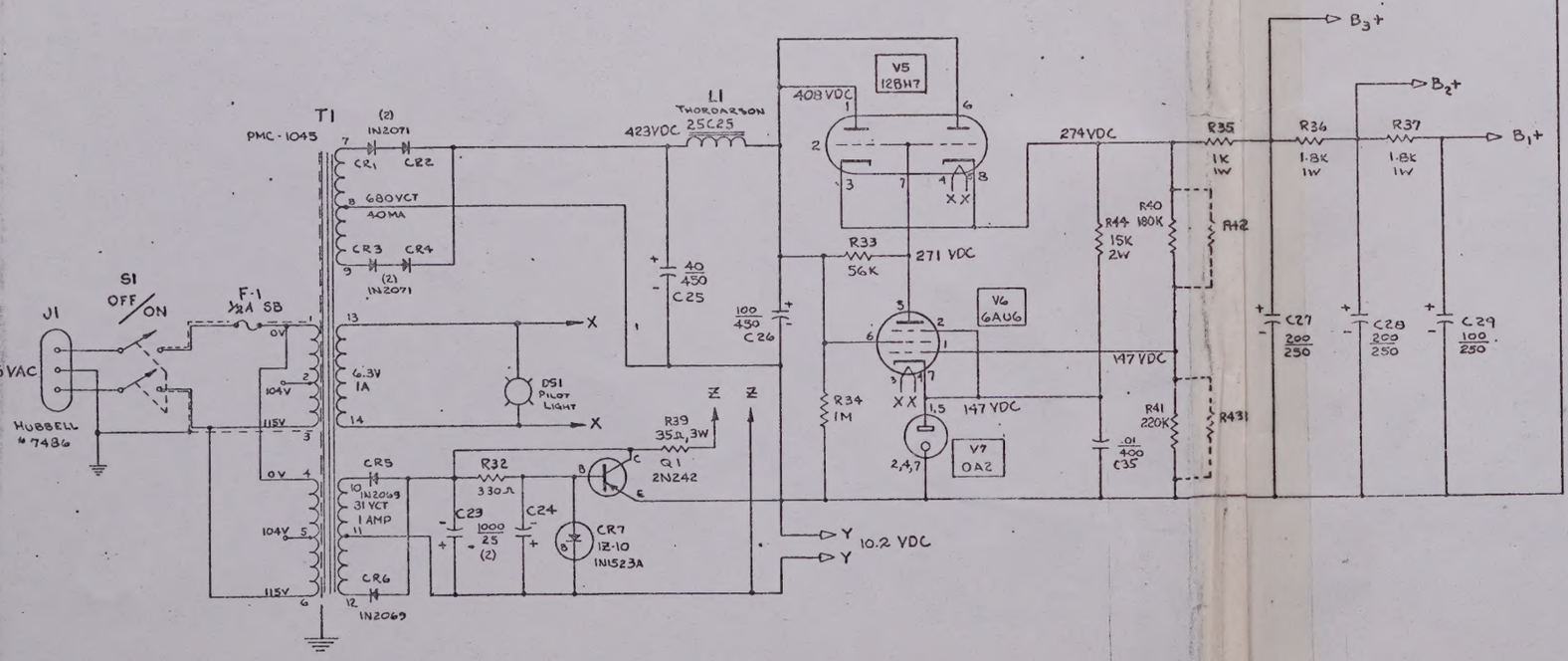
4.5 TROUBLE SHOOTING GUIDE

The following trouble shooting guide is not intended to substitute for a logical trouble shooting approach by a competent technician who understands the operation of the instrument. Should a trouble persist that cannot quickly and easily be isolated and eliminated, factory consultation is available and encouraged. Please consult the instrument warranty for information concerning repairs.

FAULT	POSSIBLE CAUSE AND REMEDY
1. Instrument plugged into known good source of power but will not operate; pilot light does not come on when the switch turned on.	1a. Blown fuse. Indicating fuse post should so indicate. Replace fuse. 1b. Check for AC voltage across pilot light terminals. Refer to schematic. 1c. Check ON/OFF Switch.
2. Instrument turns on, but gain is very low or it will not indicate any signal.	2a. Check regulated DC filament supply. Heaters of V1, V2, and V3 may or may not be seen except in a darkened room. 2b. Check B+ 2C. Check V4. Refer to schematic. 2d. Check all tubes.
3. Instrument is excessively noisy when attenuator is in "X 1000" or "X 100" position and input is short circuited.	3a. Remove V1 and check again for noise. If instrument is quiet with attenuator in "X1" position (less than 0.5% of full scale), noise is in V1 or associated components. 3b. Replace V1 and/or V2, whichever appears noisy and recheck. 3c. Check attenuator selection switch. 3d. Check C2, C4, and C6. 3e. Check input capacitors, C1, C32 and C33.
4. Instrument is noisy with attenuator in off position.	4a. Check V5, V6, and V7

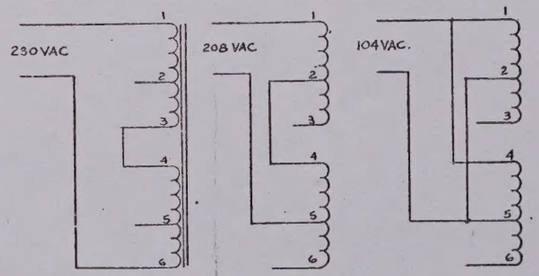
5. Signal at AC output jack, but distorted	5a. Check V4 and B+
	5b. Check V4 filament voltage. It should be between 12 and 13 VDC.
6. B+ absent	6a. Check V5, V6 and V7
	6b. Check for open or shorted resistor in power supply circuit.
	6c. Check CR1, CR2, CR3, and CR4.
	6d. Check (7, 8 and 9) winding of T1
7. Regulated filament supply (+9.4 VDC) absent.	7a. Check for voltage across 23. Should be about 18 VDC.
	7b. Check CR5, CR6 and CR7.
	7c. Check for open Q1.





GENERAL NOTES:
1. ALL RESISTORS IN OHMS ½ WATT, UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITANCE IN MFD. UNLESS OTHERWISE SPECIFIED.
3. ALL VOLTAGES ARE MEASURED WITH RESPECT TO CHASSIS GROUND WITH VTVM, UNLESS OTHERWISE SPECIFIED.

ALTERNATE TRANSFORMER PRIMARY CONNECTIONS FOR VARIOUS LINE VOLTAGE.



LAST R - R-44
LAST C - C 36

INFRARED INDUSTRIES, INC. SANTA BARBARA, CALIFORNIA

IRI MODEL 603 LOW NOISE AMPLIFIER
SCHEMATIC
Fig. 2-2

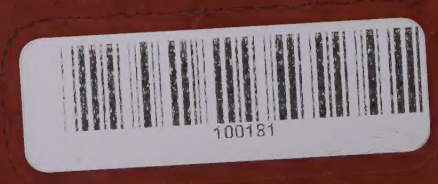
ACCOPRESS®

NO. 2507

BF - RED	BS - TURQUOISE
BG - BLACK	BQ - PALM GREEN
BD - LT. GREY	BX - EXECUTIVE RED
BP - LT. GREEN	BZ - DARK GREEN
BU - LT. BLUE	BA - TANGERINE
BY - YELLOW	BB - ROYAL BLUE

SPECIFY NO. & COLOR CODE

ACCO DIVISION OF GARY INDUSTRIES, INC.
CHICAGO, ILLINOIS 60630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